G×A=M+Č−A

LNX ROBOTS
Slovakia

RoboCup Junior Soccer
Open 2023

Parts

NAME	PCS	PRICE (€)
Bottom PCB	1	80
Motors Pololu #3202 / #3203	4	30
Motor brackets	4	5
Teensy 4.1	1	40
Regulator 12V-5V	1	< 5
Line sensors	16	1,5
Motor drivers VNH5019	4	10
GTF robots omni-wheels / homemade	4	50 / 1
Upper PCB	1	40
Raspberry Pi 4	1	75
Compass BNO055	1	50
Arducam B0310	1	40
Other		50
Robot cost	**c. 784 / 584**	

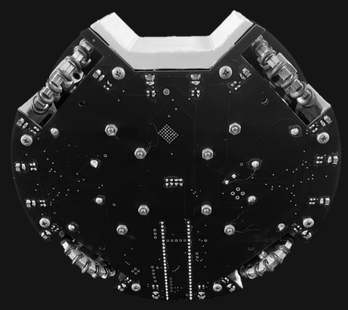
Abstract

We are LNX Robots, a team of 4 high school students, most of us are from *Gymnázium Grösslingová 18* high school in Bratislava, Slovakia.

Our robots' main chassis consist of two PCBs mounted horizontally, attached together with 3D printed covers made in Fusion 360.

On-board Raspberry Pi 4 handles object detection, logging and main playing logic.

Teensy 4.1 acts as an additional IO processing unit – controls all our 4 motors and reads from 16 line-sensors.



Bottom of the robot

Line Detection

All line detection sensors are infrared. We chose infrared light instead of visible light because of its lower interference with the environment. Also, green playfield absorbs most of the IR light, so the contrast with the lines is higher. Single line sensor consists of one infrared LED and one infrared phototransistor. Sensors have approximately the same distance between one another and are spaced out along the edge of the bottom PCB.

An algorithm takes the outermost sensors that detected line (the ones with largest angle between them) and calculates the relative position of the line defined by them. Robot then knows which direction to go to avoid the line.

Movement

Robots are equipped with 4 omnidirectional wheels

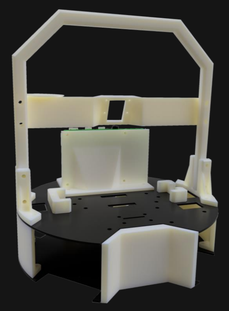
Orixa (Robot 1)
Motors: Pololu #3202, 1000 RPM, 3.9 kg · cm
Wheels: GTF robots, 50 mm

Resetlik (Robot 2)
Motors: Pololu #3203, 500 RPM, 7.4 kg · cm
Wheels: Custom made, 55 mm

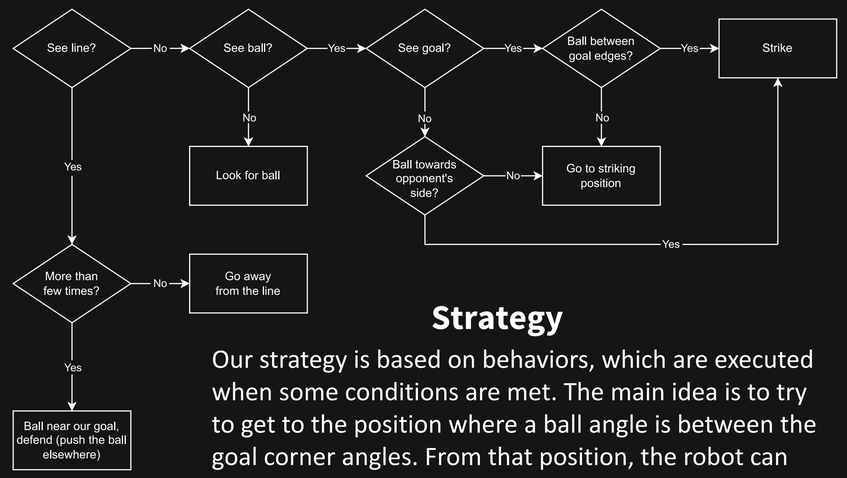
- 3D printed (way cheaper than bought ones)
- Rollers are 3D printed
  - A layer of a garden hose attached to increase friction
  - Axles – large paper clip
- Attached to the motors using Pololu Universal Mounting Hubs

First generation of the wheels weren't covered with a garden hose, which led to low friction and robot sliding and not being able to stop properly .
The third version has been improved by adding more rollers to make the ride less bumpy. These work just as well as the bought ones. However, it takes time to make them, also they are easier to become clogged with carpet threads.

Multiple generations of the omni wheels



Rendered chassis of the robot



Hardware

Bottom PCB:

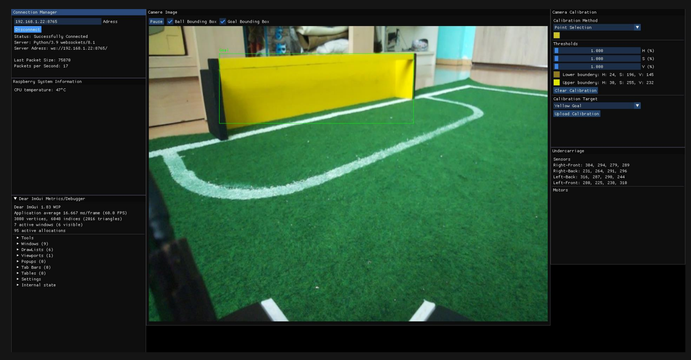
- Top side:
  - Teensy 4.1 - the main control unit of the bottom PCB
  - 4 motors – each connected to separate motor driver, angle between the motors is 90 degrees
  - VNH5019 – motor drivers, one for each motor
  - XL4015 – DC-DC converter used to convert the 12V from the battery to 5V needed to power Teensy and Raspberry Pi
- Bottom side:
  - 16x line sensors – these sensors are custom made from one IR LED and one phototransistor

Top PCB:

- Raspberry Pi 4 – the main control unit of the whole robot, used to process images from the camera
- BNO055 – IMU, used to rotate robot to the direction of the enemies' goal when it can't see it with camera. Only gyroscope mode is used
- Arducam B0310 – 120 FOV, 12MP camera used for ball and goal detection
- OLED display and buttons – used for easier control over the robot and debugging purposes

Software

Our software architecture is based on mulitprocessing. We built an API which allows us to create tasks which run the different processes and therefore speed up our program.



Strategy

Our strategy is based on behaviors, which are executed when some conditions are met. The main idea is to try to get to the position where a ball angle is between the goal corner angles. From that position, the robot can score a goal.

Robots communicate via Bluetooth to ensure more efficient gameplay. If one of the robots is closer to the ball, the other retreats to our goal to defend.

Object Detection

For object detection based on colors we use OpenCV. Raw frame from camera comes through multiple stages to finally create a bounding box around the ball or the goal.

To calibrate the detection, we use our custom-made Calibration tool (Visualizer) which allows to adapt the detection of the ball and goals to the specific light conditions and colors.

Alanata